Bioethanol from the Corn Industry

From Corn to Cellulose—Building a Bridge to Bioethanol Production

"We can get fuel from fruit, from the sumac by the roadside, or from apples, weeds, sawdust, almost anything.... And it remains for someone to find how this fuel can be produced commercially—better fuel at a better price than we now know."

Henry Ford

Fuel ethanol from corn is not a new idea

In 1908, Henry Ford designed his ModelT to run on alcohol. He continued to champion its use into the 1920s, partly because it worked, and partly because he thought it would benefit the farm industry. During the 1930s, more than 2,000 service stations in the Midwest sold ethanol (made from corn) in blends of 6%–12% with gasoline. This "gasohol" worked well in internal combustion engines, but in the 1940s was replaced by cheaper petroleum.

Our increased dependence on foreign oil for transportation, coupled with environmental concerns and legislation that requires the use of oxygenated fuels, should encourage and stimulate us to find new and more economical ways of producing this clean-burning fuel.

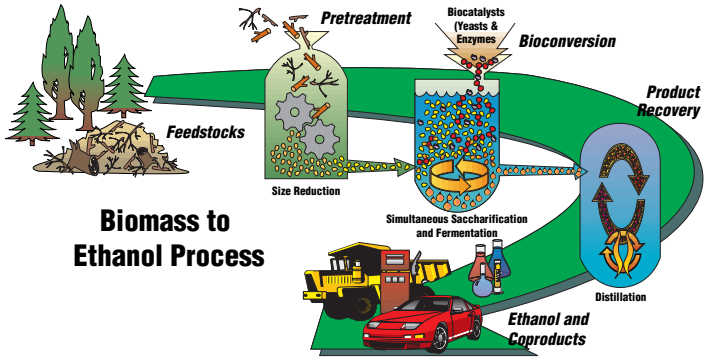
Bus that runs on ethanol

Greater Peoria Mass Transit District/PIX 03320

Making ethanol from corn fiber makes sense

In corn processing, ethanol is produced from the starch-based carbohydrate fraction of the corn kernel. But the corn fiber—that part of the kernel that contains cellulose, hemicellulose, and unconverted starch—represents about 13% of the ethanol that could be produced from the kernel. The U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) seeks ways to economically increase the yield of ethanol from biomass such as corn fiber.

With current processes, most of the starch has been converted to ethanol. The enzymes typically used to convert the starch-based carbohydrate fraction to glucose (α-amylase and glucoamylase) have only a limited effect on the cellulose and hemicellulose fractions of corn. Thus, novel technologies must be used to hydrolyze the cellulose and hemicellulose carbohydrates to sugars, which can then be fermented to produce additional ethanol.



Corn fiber-to-ethanol conversion is, in many ways, an ideal process addition to corn processing facilities because:

- Much of the infrastructure of the corn processing plant can be used, which could minimize capital and operating costs and reduce the risk of implementing new technology.
- Corn fiber (as part of the kernel) has already been purchased for the primary dry milling operation, and is therefore readily available for conversion.

The U.S. Department of Energy—a partner in ethanol production

Processor at the DOE/NREL process development unit

David Parsons, NREL/PIX 01206

A goal of DOE's Biofuels Program at NREL is to help commercialize technologies that convert lignocellulosic biomass (plant materials such as corn stalks and switchgrass) to ethanol for use as a transportation fuel. NREL, under the auspices of DOE's Office of Fuels Development (OFD), is working toward large-scale production of ethanol from biomass (called bioethanol). OFD supports research, feasibility studies, and other commercialization activities by national laboratories, universities, private industry, research foundations, and other government entities.

The NREL Biofuels Program has issued a statement of work that centers on gathering information for a specific bioethanol site. The objectives are to:

- Identify types, amounts, infrastructure requirements, and costs for potential biomass feedstocks.
- Identify typical capital equipment located at a corn processing site and determine its availability for use by a co-located bioethanol facility.
- Identify other infrastructure requirements.
- Identify community and environmental issues that surround the construction and operation of a co-located bioethanol facility.
- Determine the production capacity.
- Determine equipment needs.
- Produce a pro forma and perform sensitivity analyses on the effects of cellulase enzyme and feedstock costs on the production cost of bioethanol.

Bioethanol technology

The cost of cellulase enzymes

Currently, the cost of producing cellulase enzymes is approximately $0.45/gallon of usable ethanol. An international panel of experts recently assessed technical strategies to boost enzyme production and concluded that proven tools and techniques used in other enzyme systems could reduce the cost of enzymes to less than $0.10/gallon of ethanol.

The cost of cellulase enzymes is important to the commercial viability of a biomass ethanol facility using this technology. Cellulase enzymes are too expensive, but the enzyme industry has proven that their cost can be rapidly reduced using current technology. But because there is no market, the industry considers that the risk for return on its investment is too high, and has not yet committed its resources to working on cellulase enzymes necessary for a biomass ethanol industry.

Heightened interest on the part of corn processors and enzyme manufacturers in the corn fiber-to-ethanol industry could spur collaborations with DOE and NREL to develop more affordable enzymes.

Technology can make this happen

Researchers at NREL and elsewhere have developed tools to break down the cellulosic bonds so ethanol can be produced from the sugars. They have selected cellulase enzymes, fungi, and genetically engineered bacteria to produce large quantities of these enzymes.

Enzymes successfully break down carbohydrates into sugars, but their cost is still too high to be commercially viable. If researchers can increase the enzyme activity, and if manufacturers can produce them in quantity, the cost would drop and corn producers would be more willing to make the necessary R&D investments.

If you can make it from corn fiber, you can make it from corn stover

Corn stover (cobs, stalks, and leaves) have no food value, but are composed of the same cellulosic and lignaceous elements as fiber. Currently, most stover is plowed back into the fields to enrich the soil and prevent erosion. In a no-till environment, significant quantities of corn stover can be sustainably harvested. The same technology that can convert corn fiber to ethanol can convert the stover. If the corn processing industry is willing to take advantage of this abundant feedstock, it can reduce the volume of waste and produce much greater quantities of fuel-grade ethanol.

If you can make it from corn stover, you can make it from other things

Grasses, hays, and straws have compositions similar to corn stover, so a conversion technology that will work with corn stover will work with these materials.

Biomass feedstocks represent one of the largest sustainable resources on earth. They are produced in quantity from agricultural and forestry activities, and are largely considered to be residue and waste. They can be purchased for little or no cost, but many processors remain uninterested in using them because their advantages are negated by the costs of collection, storage, and transportation. To reduce feedstock cost, a biomass ethanol facility would need to be in the heart of a biomass-producing area. Agricultural and forest products manufacturing facilities that produce their own waste materials and are in the area of crop production already have access to low-cost biomass feedstocks.

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